

## Claims

[c1] 1.A curable resin composition, comprising:

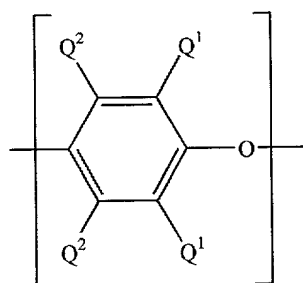
a poly(arylene ether);

an acryloyl monomer; and

an allylic monomer;

wherein the curable resin composition is a powder.

[c2] 2.The curable resin composition of Claim 1, wherein the poly(arylene ether) comprises a plurality of structural units of the formula



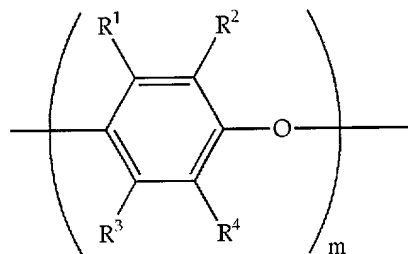
wherein for each structural unit, each  $Q^1$  is independently halogen, primary or secondary  $C_1-C_{12}$  alkyl, phenyl,  $C_1-C_{12}$  haloalkyl,  $C_1-C_{12}$  aminoalkyl,  $C_1-C_{12}$  hydrocarbonoxy, or  $C_2-C_{12}$  halohydrocarbonoxy wherein at least two carbon atoms separate the halogen and oxygen atoms;

and each  $Q^2$  is independently hydrogen, halogen, primary or secondary  $C_1-C_{12}$  alkyl, phenyl,  $C_1-C_{12}$  haloalkyl,  $C_1-C_{12}$  aminoalkyl,  $C_1-C_{12}$  hydrocarbonoxy, or  $C_2-C_{12}$  halohydrocarbonoxy wherein at least two carbon atoms separate the halogen and oxygen atoms.

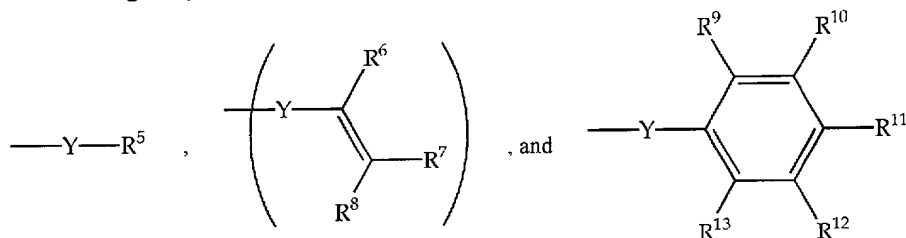
[c3] 3.The curable resin composition of Claim 1, wherein the poly(arylene ether) has a free hydroxyl group content less than about 500 micrograms per gram.

[c4]

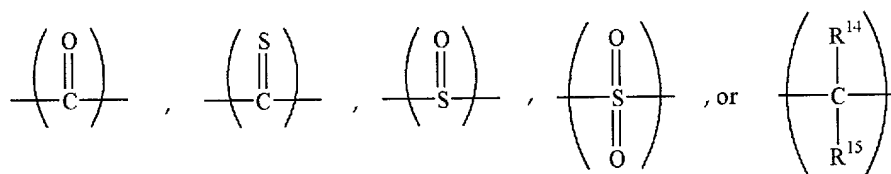
4.The curable resin composition of Claim 1, wherein the poly(arylene ether) comprises a capped poly(arylene ether) having the structure  $Q-(J-K)_y$  wherein Q is the residuum of a monohydric, dihydric, or polyhydric phenol; y is 1 to 100; J comprises recurring units having the structure



wherein  $R^1 - R^4$  are each independently selected from the group consisting of hydrogen, halogen, primary or secondary  $C_1 - C_{12}$  alkyl,  $C_2 - C_{12}$  alkenyl,  $C_2 - C_{12}$  alkynyl,  $C_1 - C_{12}$  aminoalkyl,  $C_1 - C_{12}$  hydroxyalkyl, phenyl,  $C_1 - C_{12}$  haloalkyl,  $C_1 - C_{12}$  hydrocarboxy, and  $C_2 - C_{12}$  halohydrocarboxy wherein at least two carbon atoms separate the halogen and oxygen atoms;  $m$  is 1 to about 200; and  $K$  is a capping group selected from the group consisting of



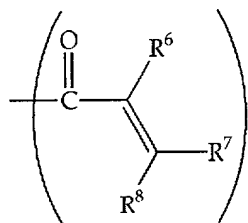
wherein  $R^5$  is  $C_1 - C_{12}$  alkyl;  $R^6 - R^8$  are each independently selected from the group consisting of hydrogen,  $C_1 - C_{12}$  alkyl,  $C_2 - C_{12}$  alkenyl,  $C_6 - C_{18}$  aryl,  $C_7 - C_{18}$  mixed (alkyl-aryl),  $C_2 - C_{12}$  alkoxycarbonyl,  $C_7 - C_{18}$  aryloxy carbonyl,  $C_8 - C_{18}$  mixed (alkyl-aryl)oxycarbonyl, nitrile, formyl, carboxylate, imidate, and thiocarboxylate;  $R^9 - R^{13}$  are each independently selected from the group consisting of hydrogen, halogen,  $C_1 - C_{12}$  alkyl, hydroxy, and amino; and wherein  $Y$  is a divalent group selected from the group consisting of



wherein  $R^{14}$  and  $R^{15}$  are each independently selected from the group consisting of hydrogen and  $C_1 - C_{12}$  alkyl.

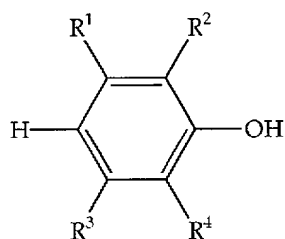
[c5]

5.The curable resin composition of Claim 4, wherein the capped poly(arylene ether) comprises a capping group having the structure



wherein  $R^6$ – $R^8$  are each independently selected from the group consisting of hydrogen,  $C_1$ – $C_{12}$  alkyl,  $C_2$ – $C_{12}$  alkenyl,  $C_6$ – $C_{18}$  aryl,  $C_7$ – $C_{18}$  mixed (alkyl-aryl),  $C_2$ – $C_{12}$  alkoxy carbonyl,  $C_7$ – $C_{18}$  aryloxy carbonyl,  $C_8$ – $C_{18}$  mixed (alkyl-aryl)oxy carbonyl, nitrile, formyl, carboxylate, imide, and thiocarboxylate.

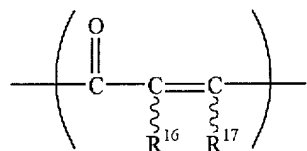
- [c6] 6.The curable resin composition of Claim 4, wherein the capped poly(arylene ether) is prepared by capping a poly(arylene ether) consisting essentially of the polymerization product of at least one monohydric phenol having the structure



wherein  $R^1$ – $R^4$  are each independently selected from the group consisting of hydrogen, halogen, primary or secondary  $C_1$ – $C_{12}$  alkyl,  $C_2$ – $C_{12}$  alkenyl,  $C_2$ – $C_{12}$  alkynyl,  $C_1$ – $C_{12}$  aminoalkyl,  $C_1$ – $C_{12}$  hydroxyalkyl, phenyl,  $C_1$ – $C_{12}$  haloalkyl,  $C_1$ – $C_{12}$  hydrocarboxy, and  $C_2$ – $C_{12}$  halohydrocarboxy wherein at least two carbon atoms separate the halogen and oxygen atoms.

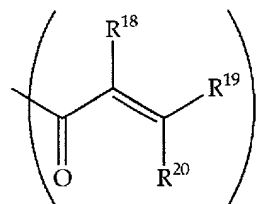
- [c7] 7.The curable resin composition of Claim 1, wherein the poly(arylene ether) has an intrinsic viscosity of about 0.1 to about 0.5 deciliters/gram in chloroform at 25 ° C.
- [c8] 8.The curable resin composition of Claim 1, comprising about 10 to about 50 parts by weight of the poly(arylene ether) per 100 parts by weight resin.
- [c9] 9.The curable resin composition of Claim 1, wherein the acryloyl monomer

comprises at least one acryloyl moiety having the structure



wherein  $\text{R}^{16}$  and  $\text{R}^{17}$  are each independently selected from the group consisting of hydrogen and  $\text{C}_1\text{--C}_{12}$  alkyl, and wherein  $\text{R}^{16}$  and  $\text{R}^{17}$  may be disposed either *cis* or *trans* about the carbon-carbon double bond.

- [c10] 10. The curable resin composition of Claim 1, wherein the acryloyl monomer comprises at least one acryloyl moiety having the structure



wherein  $\text{R}^{18}$ – $\text{R}^{20}$  are each independently selected from the group consisting of hydrogen,  $\text{C}_1\text{--C}_{12}$  alkyl,  $\text{C}_2\text{--C}_{12}$  alkenyl,  $\text{C}_6\text{--C}_{18}$  aryl,  $\text{C}_7\text{--C}_{18}$  mixed (alkyl-aryl),  $\text{C}_2\text{--C}_{12}$  alkoxy carbonyl,  $\text{C}_7\text{--C}_{18}$  aryloxy carbonyl, mixed  $\text{C}_8\text{--C}_{18}$  (alkyl-aryl)oxy carbonyl, nitrile, formyl, carboxylate, imidate, and thiocarboxylate.

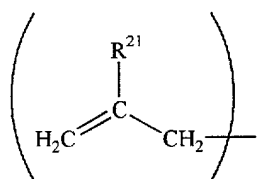
- [c11] 11. The curable resin composition of Claim 10, wherein the acryloyl monomer comprises at least two acryloyl moieties.

- [c12] 12. The curable resin composition of Claim 1, wherein the acryloyl monomer is selected from the group consisting of trimethylolpropane trimethacrylate, trimethylolpropane triacrylate, 1,6-hexanediol dimethacrylate, 1,6-hexanediol diacrylate, ethylene glycol dimethacrylate, ethylene glycol diacrylate, propylene glycol dimethacrylate, propylene glycol diacrylate, cyclohexanedimethanol dimethacrylate, cyclohexanedimethanol diacrylate, butanediol dimethacrylate, butanediol diacrylate, diethylene glycol dimethacrylate, diethylene glycol diacrylate, triethylene glycol dimethacrylate, triethylene glycol diacrylate, isobornyl methacrylate, isobornyl acrylate, methyl methacrylate, methyl acrylate, and mixtures comprising at least one of the foregoing acryloyl monomers.

[c13] 13.The curable resin composition of Claim 1, wherein the acryloyl monomer is selected from the group consisting of trimethylolpropane trimethacrylate, trimethylolpropane triacrylate, and combinations comprising at least one of the foregoing acryloyl monomers.

[c14] 14.The curable resin composition of Claim 1, comprising about 5 to about 60 parts by weight of the acryloyl monomer per 100 parts by weight resin.

[c15] 15.The curable resin composition of Claim 1, wherein the allylic monomer comprises an allylic moiety having the structure



wherein R<sup>21</sup> is selected from the group consisting of hydrogen and C<sub>1</sub>-C<sub>6</sub> alkyl.

[c16] 16.The curable resin composition of Claim 15, wherein the allylic monomer comprises at least two allylic moieties.

[c17] 17.The curable resin composition of Claim 1, wherein the allylic monomer is selected from the group consisting of allyl alcohol, methallyl alcohol, 2-ethyl-2-propen-1-ol, allyl formate, allyl acetate, allyl butyrate, allyl benzoate, methallyl acetate, allyl fatty esters, allyl methyl ether, allyl ethyl ether, allyl tert-butyl ether, allyl methylbenzyl ether, alkoxylated allylic alcohols, diallyl adipate, diallyl citraconate, diallyl diglycolate, diallyl ether, diallyl fumarate, diallyl isophthalate, diallyl itaconate, diallyl maleate, diallyl phthalate, diallyl terephthalate, triallyl aconitate, triallyl cyanurate, triallyl isocyanurate, triallyl phosphate, triallyl trimellitate, tetraallyl o-silicic acid, and mixtures comprising at least one of the foregoing allylic monomers.

[c18] 18.The curable resin composition of Claim 1, wherein the allylic monomer is selected from the group consisting of diallyl adipate, diallyl citraconate, diallyl diglycolate, diallyl ether, diallyl fumarate, diallyl isophthalate, diallyl itaconate, diallyl maleate, diallyl phthalate, diallyl terephthalate, triallyl

aconitate, triallyl cyanurate, triallyl isocyanurate, triallyl phosphate, triallyl trimellitate, tetraallyl o-silicic acid, and mixtures comprising at least one of the foregoing allylic monomers.

[c19] 19.The curable resin composition of Claim 1, wherein the allylic monomer is diallyl phthalate.

[c20] 20.The curable resin composition of Claim 1, wherein the allylic monomer is substantially free of polymerizable moieties other than allylic moieties.

[c21] 21.The curable resin composition of Claim 1, comprising about 20 to about 80 parts by weight of the allylic monomer per 100 parts by weight resin.

[c22] 22.The curable resin composition of Claim 1, further comprising a curing catalyst.

[c23] 23.The curable resin composition of Claim 22, wherein the curing catalyst is selected from the group consisting of benzoyl peroxide, dicumyl peroxide, methyl ethyl ketone peroxide, lauryl peroxide, cyclohexanone peroxide, t-butyl hydroperoxide, t-butyl benzene hydroperoxide, t-butyl peroctoate, 2,5-dimethylhexane-2,5-dihydroperoxide, 2,5-dimethyl-2,5-di(t-butylperoxy)-hex-3-yne, di-t-butylperoxide, t-butylcumyl peroxide, alpha,alpha"-bis(t-butylperoxy-m-isopropyl)benzene, 2,5-dimethyl-2,5-di(t-butylperoxy)hexane, dicumylperoxide, di(t-butylperoxy isophthalate, t-butylperoxybenzoate, 2,2-bis(t-butylperoxy)butane, 2,2-bis(t-butylperoxy)octane, 2,5-dimethyl-2,5-di(benzoylperoxy)hexane, di(trimethylsilyl)peroxide, trimethylsilylphenyltriphenylsilyl peroxide, 2,3-dimethyl-2,3-diphenylbutane, 2,3-trimethylsilyloxy-2,3-diphenylbutane, and mixtures comprising at least one of the foregoing curing catalysts.

[c24] 24.The curable resin composition of Claim 22, comprising about 0.1 to about 10 parts by weight of the initiator per 100 parts by weight resin.

[c25] 25.The curable resin composition of Claim 1, further comprising an additive selected from the group consisting of flame retardants, flame retardant

synergists, mold release agents, lubricants, antioxidants, thermal stabilizers, ultraviolet stabilizers, pigments, dyes, colorants, anti-static agents, fibrous reinforcements, disc-shaped fillers, low-aspect ratio fillers, synthetic resins, natural resins, thermoplastic elastomers, and mixtures comprising at least one of the foregoing additives.

[c26] 26.The curable resin composition of Claim 1, further comprising a filler.

[c27] 27.The curable resin composition of Claim 26, comprising a filler selected from the group consisting of silica powder, fused silica, crystalline silica, natural silica sand, boron-nitride powder, boron-silicate powder, alumina, magnesium oxide, wollastonite, calcium sulfate, calcium carbonate, talc, glass spheres, kaolin, mica, feldspar, nepheline syenite, silicate spheres, flue dust, cenospheres, fillite, aluminosilicate, quartz, quartzite, perlite, Tripoli, diatomaceous earth, silicon carbide, molybdenum sulfide, zinc sulfide, mullite, calcium silicate, zirconium silicate, barium titanate, barium ferrite, barium sulfate, aluminum, bronze, zinc, copper, nickel, carbon black, graphite, glass flakes, flaked silicon carbide, flaked aluminum diboride, aluminum flakes, steel flakes, wood flour, cellulose, cotton, sisal, jute, starch, cork flour, lignin, ground nut shells, corn, rice grain husks, polyester fibers, polyvinylalcohol fibers, aromatic polyamide fibers, polybenzimidazole fibers, polyimide fibers, polyphenylene sulfide fibers, polyether ether ketone fibers, boron fibers, silicon carbide fibers, mixed oxide fibers, silicon carbide fibers, alumina fibers, boron carbide fibers, iron fibers, nickel fibers, copper fibers, glass fibers, quartz, vapor-grown carbon fibers, combinations comprising at least one of the foregoing fillers, and combinations comprising at least one of the foregoing fillers and a surface-treating agent.

[c28] 28.The curable resin composition of Claim 1, wherein the composition is substantially free of alkenyl aromatic monomers in which an alkenyl substituent is directly bonded to an aromatic ring.

[c29] 29.The curable resin composition of Claim 1, wherein the powder is substantially free of particles having any dimension greater than about 300

micrometers.

[c30] 30.The curable resin composition of Claim 1, having a melting temperature greater than about 50 ° C.

[c31] 31.A curable resin composition, comprising:  
about 10 to about 50 parts by weight of a poly(arylene ether);  
about 5 to about 60 parts by weight of an acryloyl monomer; and  
about 20 to about 80 parts by weight of an allylic monomer;  
wherein all parts by weight are based on 100 parts by weight resin; and  
wherein the composition is a powder.

[c32] 32.A resin composition, comprising:  
about 15 to about 45 parts by weight of a capped poly(arylene ether);  
about 10 to about 40 parts by weight of a polyfunctional acryloyl monomer;  
and  
about 30 to about 70 parts by weight of a polyfunctional allylic monomer;  
wherein all parts by weight are based on 100 parts by weight resin; and  
wherein the composition is a powder.

[c33] 33.A resin composition, comprising:  
about 25 to about 35 parts by weight of a capped poly(2,6-dimethyl-1,4-phenylene ether);  
about 10 to about 20 parts by weight of trimethylolpropane triacrylate or trimethylolpropane trimethacrylate; and  
about 50 to about 60 parts by weight of diallyl phthalate;  
wherein all parts by weight are based on 100 parts by weight resin; and  
wherein the composition is a powder.

[c34] 34.A cured resin composition, comprising the reaction product of:  
a poly(arylene ether);  
an acryloyl monomer; and  
an allylic monomer;  
wherein the cured resin composition is the cured product of a curable



powder resin composition.

- [c35] 35.The cured resin composition of Claim 34, having a fracture toughness value, K<sub>1C</sub>, measured according to ASTM D5045 of at least about 0.9 Mpa-m<sup>1/2</sup>.
- [c36] 36.An article comprising the composition of Claim 34.
- [c37] 37.A method of forming a curable resin composition, comprising:  
blending a poly(arylene ether) and an allylic monomer to form a first intimate blend;  
blending the first intimate blend and an acryloyl monomer to form a second intimate blend; and  
processing the second intimate blend to form a curable powder.
- [c38] 38.The method of Claim 37, wherein processing the second intimate blend to form a curable powder comprises grinding at a temperature less than about -75 ° C.
- [c39] 39.The method of Claim 37, further comprising blending the curable powder with a curing catalyst.
- [c40] 40.A method of preparing a curable composition, comprising:  
blending about 20 to about 80 parts by weight of an allylic monomer with about 10 to about 50 parts by weight of a poly(arylene ether) to form a first intimate blend;  
blending the first intimate blend with about 5 to about 60 parts by weight of an acryloyl monomer to form a second intimate blend;  
grinding the second intimate blend at a temperature less than about -75 ° C to form a first curable powder; and  
blending the first powder with a curing catalyst to form a second curable powder;  
wherein all parts by weight are based on 100 parts by weight resin.